Appendix E

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Managed forest lands on the refuge

Forest Management Guidelines

Forest Management Guidelines

Introduction

The purpose of this appendix is to provide further detail on our proposed forest management under the Lake Umbagog Refuge Final CCP/EIS alternative B. It includes information on the desired future condition of our upland forested habitats, focusing on those areas within the current refuge boundary where we expect to operate in the next 15 years. We describe anticipated growth rates, harvest rates, and management techniques that will be used to achieve our habitat management goals and objectives.

Desired Future Forest Condition

We describe a landscape analysis we conducted in appendix H. It resulted in our determination that sustaining a mature, unfragmented, mixed spruce-fir/northern hardwood forest matrix, with a high conifer component, to benefit those species dependent on this type of forest landscape, was the most important ecological contribution the refuge could make through management to the Upper Androscoggin River watershed, the Northern Forest, and the Refuge System.

The 15 year scope of our CCP falls far short of the decades we expect it will take to create a sustainable mature mixed forest. Our expectation is that it will take at least 100 years to fully implement our forest management goals and objectives. This timeframe is based on our prediction of how long it will take to achieve the forest and stand composition and structural characteristics targeted for our refuge focal species identified in the alternative B. Generally, our management will increase the percentage of spruce and fir in our forests, and move our stands toward a mature forest structure, including super canopy trees, and with a high degree of canopy closure. This management will benefit certain refuge focal species, including blackburnian and black-throated green warblers. In woodcock focus areas, management to benefit two other focal species, Canada warbler and American woodcock, will be emphasized. Also, we will improve deer wintering areas, where consistent with our management for focal species. We will plan our management to ensure that large blocks of unfragmented habitat are consistently available over time, for those species that require it. We will also assess the effects of our management at a refuge scale, in order to ensure connectivity between habitat patches. We believe our management will help to build the resilience of our forests to multiple stressors , in the face of climate change, but may have to adjust our management approach as conditions require.

Sustaining a mature mixed forest over the long term requires active management of all forest age and structural classes, which we have grouped in our discussions throughout the Final CCP/EIS into: regeneration, mid- and mature age classes. Silvicultural approaches will differ in different habitat types within the mixed forest, but management will stay within the inherent capability of the site to grow certain tree species (i.e. based on soil properties, moisture regimes, elevation, aspect, etc). Attachment 1 defines techniques we might employ. Where feasible, and assuming favorable site capabilities, our management strategies will favor or increase the spruce-fir component of stands. We will also predominately use forest management techniques to promote uneven-aged stands which we believe will best achieve our habitat goals and objectives. There are some sites, however, where techniques to promote even-aged stands would better meet our objectives. This may occur, for example, in stands where we want to encourage advanced regeneration of spruce/fir, enhance deer wintering areas, and/or to manage for American woodcock and Canada warbler.

Our Final CCP/EIS alternative B (Service-preferred alternative), Objective 3.1 Mixed Spruce-Fir/Northern Hardwood Forest reads:

Conserve the mixed spruce-fir/northern hardwood forest on Service-owned lands within the current and expanded refuge boundaries, to sustain well-distributed, high quality breeding and foraging habitat for species of conservation concern, including blackburnian, black-throated green, and Canada warblers, and American woodcock. Also, where consistent with management for those focal species, protect critical deer wintering areas and provide connectivity of habitat types for wide-ranging mammals.

It is important to understand that our management efforts will focus on providing sustainable high quality habitat conditions for our focal species. As noted above, in order to accomplish this, we would need to manage the various age classes and structures to ensure habitat conditions can be provided over the long-term. It is also important to understand that not every acre on the refuge is forested, nor is every forested acre suitable for active management. Furthermore, not every forested acre on refuge land is adequately stocked. In fact, many parcels of land purchased for the refuge over the last few years have been heavily harvested prior to sale. In these areas, very little, or no, management may be warranted to meet our habitat and focal species objectives during the 15year lifetime of this plan.

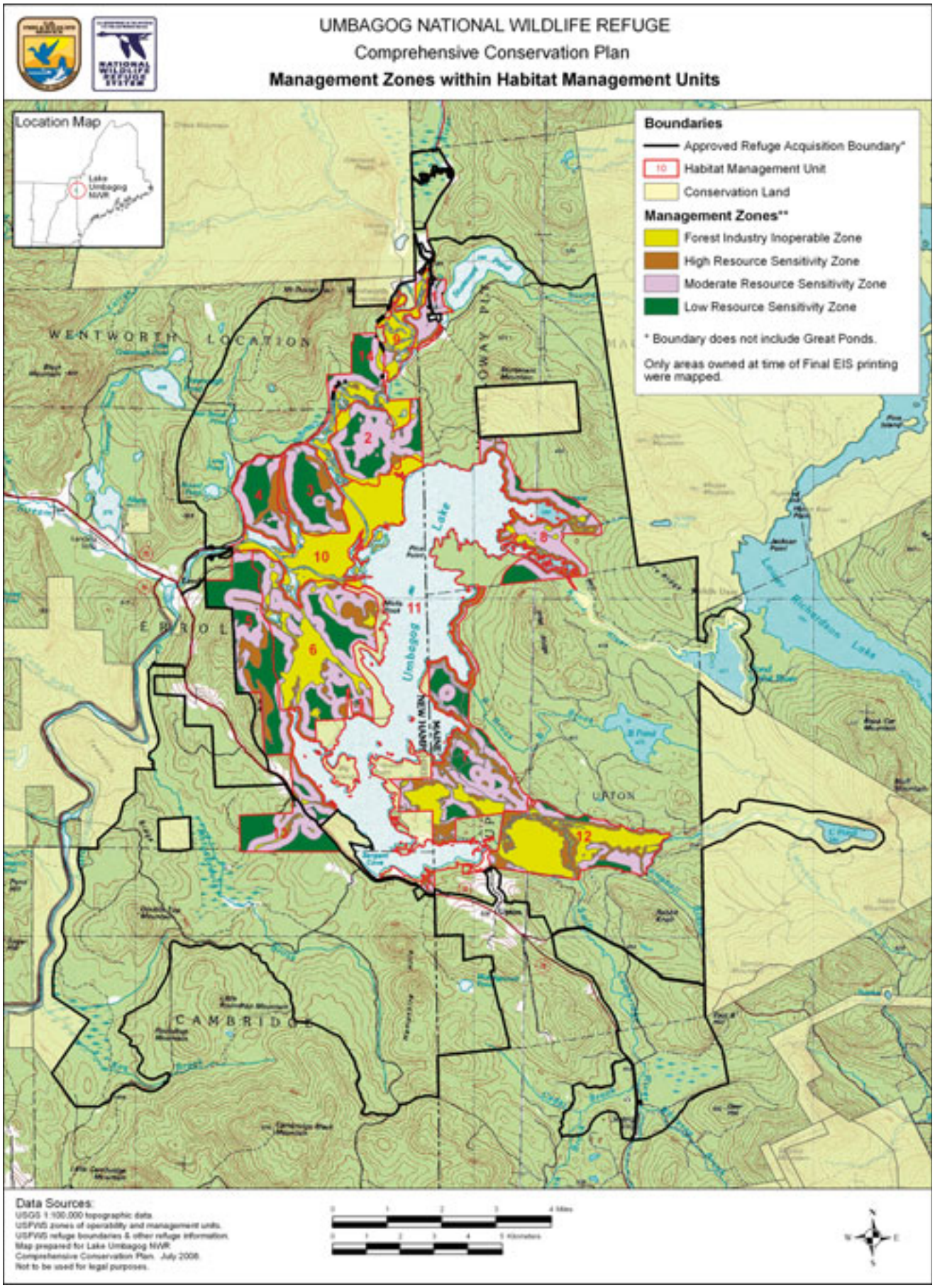
Identifying Management Zones

In conjunction with our habitat type mapping we determined management zones, or zones of operability, to help identify where active management is possible (map E-1). These zones were mapped using stand level vegetation, wetlands, and soils information, and our knowledge of wildlife use. We define below the following four zones: 1) Low Resource Sensitivity (least restrictive; fewest special management prescriptions needed); 2) Moderate Resource Sensitivity; 3) High Resource Sensitivity; and, 4) Forest Industry Inoperable. Best states' recommended forest practices, in terms of both forestry and wildlife management, will be followed in all areas and zones (see below: New Hampshire Forest Sustainability Standards Work Team 1997; Flatebo et al. 1999; Cullen 2000; Calhoun and DeMaynadier 2003; Smith and Whitney 2001; Chase et al. 1997; Reay et al. 1990).

Low Resource Sensitivity Zone: Stands within this zone allow for the greatest flexibility in managing over the long term to diversify forest age class and structure to benefit our focal species. A variety of commercial and noncommercial timber harvesting may occur as described below under each habitat type. All harvesting will follow best forestry and wildlife management practices (BMPs), as recommended by the states of New Hampshire and Maine. Where this zone surrounds or abuts moderate and high sensitivity and industry inoperable zones, stand prescriptions will reflect the need to protect or enhance the resource values on those adjacent, more sensitive areas.

Moderate Resource Sensitivity Zone: Stands within this zone are subject to more restricted silvicultural prescriptions or timing of harvest than in the Low Resource Sensitivity Zone. Restrictions may include (but are not limited to) seasonal operational closures, maintenance of closed canopy conditions, retention of coarse woody debris or snags, etc.

High Resource Sensitivity Zone: Stands within this zone are subject to very few manipulations. We may fell, girdle, or otherwise treat individual trees, or small groups of trees, to benefit wildlife or for safety reasons. Highly restrictive areas may include excessively steep slopes, hydric soils, and/or close proximity to resources of concern, such as streams and wetlands. Most of these areas are also considered "inoperable" by the forest products industry (see below); however, the refuge's high resource sensitivity zone is more extensive than what industry would consider "inoperable".


UMBAGOG NATIONAL WILDLIFE REFUGE
Comprehensive Conservation Plan
Management Zones within Habitat Management Units
Location Map
Lake Umbagog NWR
Boundaries
Approved Refuge Acquisition Boundary*
Habitat Management Unit
Conservation Land
Management Zones**
Forest Industry Inoperable Zone
High Resource Sensitivity Zone
Moderate Resource Sensitivity Zone
Low Resource Sensitivity Zone
* Boundary does not include Great Ponds.
Only areas owned at time of Final EIS printing were mapped.
WENTWORTH LOCATION
Umbagog Lake
Lower Richardson Lake
CAMBRIDGE
Data Sources:
USGS 1:100,000 topographic data
USFWS zones of operability and management units.
USFWS refuge boundaries & other refuge information.
Map prepared for Lake Umbagog NWR
Comprehensive Conservation Plan. July 2008.
Not to be used for legal purposes.

Forest Industry Inoperable Zone: This zone represents local forest industry standards for inoperability. These areas were mapped by the former timber company landowner. This zone includes stands that are non-forested wetlands, or are too steep or wet to be economically harvested (Johnson 2003). We may fell, girdle, or otherwise treat individual trees, or small groups of trees, to benefit wildlife or for safety reasons; otherwise, tree harvest will be quite limited.

List of Guidelines /Best Management Practices

At a minimum, our forest management will adhere to recommended best management practices for forest and wildlife management listed in the documents below:

Calhoun, A.J.K. and P. deMaynadier. 2003. Forestry habitat management guidelines for vernal pool wildlife in Maine. U.S. Environ. Protect. Agency, Boston, MA.

Chase, V., L. Deming and F. Latawiec. 1997. Buffers for wetlands and surface waters: a guidebook for New Hampshire municipalities. Audubon Soc. of New Hampshire

Cullen, J.B. 2000. Best management practices for erosion control on timber harvesting operations in New Hampshire. NH Dept. of Resources and Economic Development, Div. of Forests and Lands, Forest Info. and Planning Bureau and Univ. of New Hampshire Coop. Extension.

Flatebo, G., C.R. Foss and S. K. Pelletier. 1999. Biodiversity in the forests of Maine: guidelines for land management. C.A. Elliott, ed. Univ. of Maine Coop. Extension. UMCE Bulletin # 7147.

New Hampshire Forest Sustainability Standards Work Team. 1997. Good forestry in the granite state: recommended voluntary forest management practices for New Hampshire. N.H. Div. of Forests & Lands, DRED and Soc. for the Protection of NH Forests.

Reay, R.S., D.W. Blodgett, B.S. Burns, S.J. Weber, and T. Frey. 1990. Management guide for deer wintering areas in Vermont. Vermont Dept. of forests, Parks 7 Rec. and Dept. of Fish & Wildlife.

Smith, S. and S. Whitney. 2001. Guide to New Hampshire timber harvesting laws. Univ. of New Hampshire Coop. Extension.

Identifying Habitat Management Units

To facilitate the development of a detailed habitat management plan (HMP), we divided all refuge lands currently under fee ownership into 14 geographic areas or "habitat management units (HMUs)" (map K-1). The HMP, which is a step-down plan to be completed immediately upon CCP approval, will detail stand-level treatments and prescriptions (e.g. timing, distribution, method or technique, etc) for each HMU. Our HMU boundaries are defined based on ecological systems and landscape features such as roads, waterways, Umbagog Lake, as well as logistical considerations.

Defining Manageable Forest Areas

Of the 21,644 acres owned by the refuge in fee (an additional 6 acres are owned in easement) and delineated in HMUs, 10,845 acres of that is considered upland forest. Of those upland forest acres, more than half falls within high resource sensitivity or forest industry inoperable zones, or includes stands recently harvested and existing in regeneration through sapling/pole age classes. Our management would be limited in these areas. Instead, the focus of our forest management to benefit focal species will fall within existing mature stands within the low and moderate resource sensitivity zones.

We determined where we currently have mature stands through two sources. The first was aerial photo interpretation work conducted for us under contract by James W. Sewall Company. We used their data to identify mature stands which we defined as having a canopy height greater than 30 feet in spruce-fir and mixed woods, and 50 feet in hardwoods. We also utilized information from a timber inventory conducted in 2000 and supplied to us by the previous owner. We used this information to further identify mature habitat conditions, and to evaluate stocking levels and forest products potential associated with each of the habitat types described below.

Table E.1 presents a summary of the acreage on which we will focus forest management over the next 15 years to benefit focal species. It represents the upland forest habitat types, currently owned in fee by the refuge, that are in a mature age class and stand condition, and occur in low or moderate resource sensitivity zones. We refer to these acres as "manageable" in the table below.

Table E.1. By forest habitat type, the acres in upland that are owned in fee, and the resulting predicted "manageable" forest habitat acres on the Lake Umbagog Refuge under the Final CCP/EIS, Alternative B: Service-preferred alternative

Forest Habitat Type	Upland Forest Acreage Owned in Fee	Predicted Manageable Acres Over Next 15 Years
Northern Hardwood	4,640	804
Spruce-fir	2,346	1,032
Mixed Woods	3,859	2,205
TOTAL	**10,845 acres**	**4,041 acres**

Limited forest management may also need to occur during the 15 year life-span of this plan in the remaining 5,872 acres of upland forest not meeting the aforementioned criteria. Of those acres, some habitat improvement projects, such as pre-commercial thinning, may be implemented to support our objectives in those stands that exist in the regeneration and sapling/pole size age classes, and in the low and moderate resources sensitivity zones. This will be determined after we conduct a detailed stand inventory. Timber sale areas will be managed and in some cases combined, in order to ensure their commercial viability. The remaining acres, which occur in the high resource sensitivity or in the forest industrial inoperable zones, will largely be unmanaged, but will contribute towards the mature age class in our desired future condition.

Proposed Management by Forest Habitat Type

The following proposed management may be employed by the refuge under full-implementation of the Final CCP/EIS alternative B to achieve the desired future condition over the long-term. It includes commercial and non-commercial forest management on low to moderate resource sensitivity zones designed to meet our focal species habitat management objectives. These descriptions represent anticipated management and resulting harvest figures. More detailed prescriptions by treatment unit will be developed in the HMP and will be based on individual site conditions. Also, Attachment 1 describes the silvicultural techniques in more detail.

Spruce-fir

Desired future condition for focal species: Mature, closed canopy conifer with a high spruce component.

Uneven-aged Management
In the refuge's spruce-fir forested stands, we will utilize uneven-aged management techniques to convert the predominately even-aged forest to a multi-aged, multi-structured condition. We plan to conduct harvest utilizing a combination of group selection, with some single tree selection between groups. Groups should be roughly 1/10 acre in size and will be distributed throughout the entire management unit with 10-15% of the area being removed on 15-20 year cycles. Age class goals, not including reserve snag and cavity trees, will be 100-130 years. Basal area (BA) goals in spruce-fir should strive for a minimum of 80 ft^2/acre, with roughly 50% in 6-10" diameter class, 30% in 11-14" diameter class, and 25% in a 15"+ diameter class. Our spruce-fir structural goals are to maintain a q=1.7, which has about a 45% of its diameter distribution in an 11"+ diameter class. Use of the "q" is defined by Leak et al.:

Diameter distributions are approximated by the reverse J-shaped curve, with a slope defined by "q" – the quotient between numbers of tree in successively smaller d.b.h. classes."

We predict a stand at this stocking level will grow at a rate of 2 ft^2/ acre/year resulting in 30-40 ft^2/acre of volume available to harvest during each cutting cycle. Of this growth, we estimate retention of approximately 7 ft^2/ acre (approximately 6 trees/acre), to account for our snag and cavity tree requirements resulting in the potential removal of 23-33 ft^2/acre during each harvest entry.

It is expected a minimum net annual growth in this habitat will be .3 cords/acre/year which, over a 15-20 year period, equates to 4.5-6 cords/acre net increase. During each harvest entry, a portion of the trees need to be retained to fulfill our snag and cavity tree requirements. Individual trees (11"-20" diameter) are estimated to consist of .25 - 1 cord. It is predicted a retention volume of 2-3 cords/acre (1000-1500 BF/acre), distributed among 6 trees/acre, will be adequate to attain the desired snag/cavity tree goals. This results in roughly 2.5-4 cords/acre (1250-2000 BF/acre) available to harvest during each harvest cycle entry. Because our diameter distribution is skewed more towards the larger 11-14" class, it is predicted our gross volume will be 20-25 cords/acre at the beginning of each harvest cycle. With the predicted even distribution of volume per acre, this equates to 15 % area removal at each entry, accounting for 3-3.5 cords/acre, and any remaining volume/acre needed to meet the habitat goal, being removed through single tree selection.

Even-aged Management
In certain areas, such as where there is healthy, advanced spruce-fir regeneration or in critical deer wintering areas, we may employ even-aged management techniques in this habitat type. This is consistent with our objective to perpetuate a multi-aged and multi-structured forest landscape. We would conduct harvests utilizing shelterwood or clearcuts in a shifting mosaic pattern that will result in a progressive patch, block, or strip system, where-in typically 15% of the area is harvested in 15 – 20 year intervals.

Target rotation age is 80-130 years. On 15 year harvest cycles, and an approximate 100 year rotation, this equates to roughly 6 age classes with 33.3% of the area in a 0-30 year age class (regeneration/sapling structural stage), 33.3% in a 30-60 year age class (pole/small sawtimber structural stage), and 33.3% in a 60-100 year age class (small sawtimber/large sawtimber structural stage). If no significant natural disturbance occurs during the rotation of a treatment area, basal area (BA) at the time of harvest will likely be above 140 ft^2/acre, and may be in excess of 200 ft^2/acre. Scheduling of a harvest is not basal area dependent, and is considered to be the size of the treatment area in its entirety, which is approximately 15% of the HMU.

Snag and cavity trees will need to be retained through a reserve approach during each harvest. We estimate retention of approximately 7 ft²/acre (e.g. approximately 6 trees/acre) to account for our snag and cavity tree requirements. Manipulative efforts through habitat improvement may need to be employed on adjacent areas to account for potential loss of this component from sudden exposure to sun, wind, storm, insect or other natural agents.

Harvest volume will vary greatly by site but 25 to 50 cords per acre is expected from 100 year old, unmanaged, fully stocked even-aged stands. Approximately 2 cords per acre will need to be retained for snag and cavity tree requirements.

Clearcuts on the refuge will be limited in size and typically less than 10 acres; or, in deer winter yards, clearcuts will be one of several regeneration methods used, but would not be applied on more than 20% of a deer wintering area within a 15-year interval.

Mixed Woods

Desired future condition for focal species: Mature, closed-canopy habitat with a high conifer (spruce-fir) component.

Silvicultural approaches will differ within the mixed spruce-fir/northern hardwood forest matrix based on the inherent capability of an individual site to grow a predominance of either spruce/fir or northern hardwoods (i.e. based on soil properties, moisture regimes, elevation, aspect, etc). Habitat types will be perpetuated through time, using accepted silvicultural practices. Where feasible, and assuming favorable site capability, management strategies will favor or increase the conifer component of stands.

Uneven-aged Management

In the refuge's mixed woods stands, we will primarily utilize uneven-aged management techniques to convert the predominately even-aged forest to a multi-aged, multi-structured, condition. We will conduct harvests utilizing a combination of group selection with some single tree selection between groups. Groups should range from 1/5 to 1/2 acre in size and be distributed throughout the entire management unit with 10-15% of the area being removed on 15-20 year cycles. Age class goals, not including snag and cavity trees, should be 100-200 years. BA goals in mixed woods should strive for a minimum of 100 ft²/acre with roughly 42% in a 6-10" diameter class, 28% in 11-14" diameter class, and 30% in a 15"+ diameter class. Mixed woods structural goals are to maintain a q = 1.5, which has about 55% of its diameter distribution in an 11"+ diameter class.

We predict a stand at this stocking level will grow at a rate of 2 ft²/ acre/year resulting in 30-40 ft²/ acre available to harvest during each cutting cycle. Of this growth, we estimate retention of approximately 7 ft²/acre (e.g. approximately 6 trees) to account for our snag and cavity tree requirements resulting in a removal of 23-33 ft²/ acre during each harvest entry.

We expect a minimum net annual growth in this habitat will be .33 cords/acre/ year, which over a 15-20 year cutting cycle, equates to a 5-6.5 cords/acre net increase. During each harvest entry, a portion of the trees need to be retained to fulfill our snag and cavity tree requirements. Individual trees (11"-20" diameter) are estimated to consist of .25 - 1 cord. It is predicted a retention volume of 3 - 4.5 cords/acre (1500-2250 BF/acre) distributed among 6 trees/acre will be adequate to retain the desired snag/cavity tree goals. This results in approximately 2-3 cords (1000-2000 BF/acre) available to harvest during each harvest cycle.

Because our diameter distribution is skewed more towards the larger 11-14" class, it is predicted our gross volume will be 18-22 cords/acre at the beginning of each harvest cycle. With the predicted even distribution of volume per acre this equates to 10 - 15 % area removal at each entry, accounting for 2 - 3.5 cords/acre, and the remaining volume/acre needed to meet the habitat goal, being removed through single tree selection.

Even-aged management
Where site conditions and management goals deem appropriate (deer wintering areas and areas where advanced spruce/fir regeneration exists), we will employ the even-aged management techniques as described for spruce/ fir management. These techniques will be used to perpetuate a multi-aged and multi-structured forest landscape through even-aged area regulation. We plan to conduct harvests utilizing shelterwood or clearcuts in a shifting mosaic pattern that will result in a progressive patch, block, or strip system, where-in 15% of the area is harvested in 15 – 20 year intervals.

Northern Hardwoods
Desired future condition for focal species: Mature, mid-high canopy closure, with a multi-layered profile, and canopy gaps with understory development.

Uneven-aged Management
In the refuge's northern hardwood stands, we will utilize uneven-aged management techniques to convert the predominately even-aged forest to a multi-aged, multi- structured condition. We will conduct harvests utilizing a combination of group selection with some single tree selection between groups. Groups would be approximately 1/2 acre in size and be distributed throughout the entire management unit with 10-15% of the area being removed on 15-20 year cycles. Age class goals, not including snag and cavity trees, should be 100200 years. BA goals in northern hardwoods should strive for a minimum of 70 ft^2/ acre with roughly 42% in a 6-10" diameter class, 28% in 11-14" diameter class, and 30% in a 15"+ diameter class. Northern hardwoods structural goals are to maintain a q = 1.5, which has about 55 % of its diameter distribution in an 11"+ diameter class.

We predict a stand at this stocking will grow at a rate of 2 ft^2/ acre/year resulting in 30-40 ft^2/ acre available to harvest during each cutting cycle. Of this growth, we estimate retention of approximately 7 ft^2/acre (e.g. approximately 6 trees), to account for our snag and cavity tree requirements, resulting in a removal of 23-33 ft^2/acre during each harvest entry.

We expect a minimum net annual growth in this habitat will be .4 cords/acre/ year, which over a 15-20 year period, equates to a 6-8 cords/acre net increase. During each harvest entry a portion of the trees need to be retained to fulfill our snag and cavity tree requirements. Individual trees (11"-20" diameter) are estimated to consist of .25 - 1 cord. We predict a retention volume of 2-3 cords/ acre (1000-1500 BF/acre) distributed among 6 trees/acre will be adequate to attain the desired snag/cavity objectives. This results in approximately 4-6 cords (2000-3000 BF/acre) available to harvest during each harvest cycle entry.

Because our diameter distribution is skewed more towards the larger 11-14" class, it is predicted our gross volume will be 18-22 cords/acre at the beginning of each harvest cycle. With the predicted even distribution of volume per acre, this equates to 10-15 % area removal at each entry, accounting for 2 - 3.5 cords/acre, and the remaining volume/acre needed to meet the habitat goal, being removed through single tree selection.

Woodcock Focus Areas

Even-aged Management
In woodcock focus areas, we will use accepted silvicultural practices to create openings, promote understory development, and sustain early successional habitat for woodcock and Canada warbler. We will use group selection, clearcuts, or patch cuts of up to 5 acres in size. Some larger roosting fields may also be maintained. Cutting cycles will be approximately 8-10 years on a 40 year rotation. Some 3-5 acre openings may be permanently maintained, primarily by mowing and brush clearing using mechanized equipment. We will perpetuate the aspen-birch community where it currently exists, and maintain it in well-distributed regenerating, young, mid- and mature age classes.

Anticipated Average Annual Harvest Summary

Table E.2 presents the average annual volume and forest product that would result from the stand management described above for the Final CCP/EIS alternative B.

Table E.2. Predicted forest products and average annual harvest volumes under implementation of the Lake Umbagog Refuge Final CCP/EIS alternative B.

Forest Product	Average Annual Quantity under CCP Alternative B
Softwood Sawtimber	135 MBF
Hardwood Sawtimber	27 MBF
Softwood Pulp	125 Cords
Hardwood Pulp	371 Cords
Fuelwood	88 Cords

Anticipated Management on Lands to be Acquired in the Proposed Expansion Area

Over the next 15 years, as land is acquired from willing sellers in functional management units of at least 200 contiguous acres, we will delineate a new HMU and undertake the same evaluation we conducted for current refuge lands. Within two years of acquisition, we will conduct a stand inventory and apply the resource sensitivity zones. We will then develop management prescriptions to support the same goals and objectives for our focal species, using the same methodology we described above for current refuge lands.

Attachment 1

Definitions of Forest Silvicultural Techniques and Methods to Use in our Forest Management for Focal Species

Group Selection
This technique involves the removal of small groups of trees throughout a stand, to initiate and/or maintain an uneven-aged forest. A group selection opening is considered to be less than, or equal to, twice the height of the adjacent mature trees. This method will encourage regeneration of intermediately tolerant and tolerant species, but some intolerant species can appear towards the center of the harvest areas when the groups are at the maximum size. The likelihood of the harvest areas regenerating combined with the ability to schedule continual harvest entries, results in this technique being a method of choice to convert even-aged stands to uneven-aged stands when desired.

Group selection results in moderately- closed to closed-canopy conditions. Regeneration and shrubby vegetation can be expected to develop with reasonable assurance. This technique can be used in combination with singletree selection to ensure canopy closure requirements meet desired conditions. Priority species such as the blackburnian and black-throated green warbler will benefit from the application of this technique in a conifer-dominated habitat area. The predominantly closed canopy condition resulting from this technique will also benefit deer winter cover areas. The technique can be applied in all habitat types. Its application in the refuge's spruce-fir forest most closely resembles the natural disturbance that would be expected to take place if the area were allowed to develop without manipulation.

Single Tree Selection
This technique involves the removal of individual trees throughout a stand. Use of this technique, on a continual harvesting cycle, is considered uneven-aged management. It can also be used during even-aged management, and when done so, is commonly referred to as an intermediate thinning. In uneven-aged management, it is used to introduce small openings in the canopy by focusing the harvest on dominant, older aged trees. In even- aged management, it is used to promote the quality and growth of the remaining trees by focusing the harvest on poor quality, low vigor trees. The technique will likely result in varying quantities of regeneration of mostly shade tolerant species.

Single tree selection results in a relatively closed canopy condition. Understory development is usually minimal. The opportunity for regeneration is created but when trees are selected singularly, the opening produced in the canopy will typically be utilized quickly by the crowns of adjacent older trees. This technique is often used in combination with group selection to ensure regeneration is established and separate age classes are created to perpetuate the overall desired condition. In using single tree selection, with even-aged objectives in the form of a thinning, it will likely result in less opportunity for regeneration and understory development. Often times the suppressed and co-dominant trees are selected for removal resulting in very little change in canopy closure after a treatment. This technique can be applied in all habitat types.

Pre-commercial Stand Treatments to Improve Habitat Conditions
These treatments include entering an even- or uneven-aged stand at any stage of development with the intent of tending to habitat needs through thinning, weeding, cleaning, liberation, sanitation, or other improvement methods. This technique can be used to control species composition and reduce an overabundance of stems per acre to a more desired stocking level. This can be applied through thinning young stands (pre-commercially) to control species composition, conducting intermediate thinnings in middle aged stands to maintain accelerated growth and remove unwanted vegetation, and prescribed

fire. This technique may also be used to control stocking levels of habitat features such as snag trees, cavity trees, den trees, downed wood and other features through girdling, felling, boring, hinging, or other techniques.

This habitat improvement technique is varied in its application, but overall should be applied to alter or enhance young stands and introduce or reduce habitat features when goals and objectives are not being met. This can be applied in all habitat types and may be extended to areas that are not capable of supporting equipment for larger scale manipulation efforts.

Shelterwood System
This technique involves a series of harvests carried out with the intent of regenerating a stand utilizing mature trees that are removed at the end of the scheduled rotation. Essentially, the overstory is removed and the well-developed underlying regeneration then becomes the stand. This technique is typically used to regenerate intermediately tolerant (mid successional) and tolerant (late successional) species, but in certain instances can be used for intolerant (early successional) species. Use of this technique is considered even-aged management, although variations more often found in the irregular shelterwood system can result in a multi-aged stand. In order for a shelterwood system to be considered, a stand should be reasonably well stocked with a moderate to high component of the species desired for regeneration.

A number of shelterwood system applications exist. The more commonly used is the open shelterwood system. Although less commonly used, the dense shelterwood, deferred shelterwood, irregular shelterwood, natural shelterwood, and nurse tree shelterwood systems are also useful in accomplishing specific regenerative needs as well as other resource management objectives.

The shelterwood variations allow a variety of habitat conditions to be created while fulfilling the regenerative objectives of the technique. It can be used to create a denser crown closure when connectivity of an older age forest needs to be maintained. The amount of time needed to establish regeneration and conduct the overstory removal can provide enough time for other areas to develop into an older age condition, and ensure refuge goals are being met continually. Overstory removal can be delayed through a deferred shelterwood if further development of other areas is necessary. It can also be used to create a more open crown closure when development of a shrub component in the understory is desired or residual tree are needed to meet specific habitat requirements. Once regenerative needs have been reached and the “shelter” (seed) trees have been removed, the new stand can then be managed for structural objectives as it develops. Overstory removal can result in a regenerative condition which does offer some early successional benefits as described in the clearcut technique.

This technique can be used in all habitat types. Its application on habitats comprised of predominately shallow root species (e.g. red spruce/balsam fir) or wet soil conditions, does introduce a greater susceptibility of the residual trees to windthrow from wind events.

Clearcutting
This technique involves the removal of an entire stand of trees in one cutting to obtain natural reproduction. Two common methods of clearcutting are patch or block clearcuts, and strip clearcuts. This regeneration technique is considered to be even-aged management, although somewhat coarse multi-aged stands can be developed through progressive patch or progressive strip clearcut systems. Clearcut size does have an effect on regeneration. As clearcuts increase in size,

they tend to favor shade intolerant regeneration. As they become smaller they gravitate towards encouraging intermediately tolerant and tolerant species.

Clearcuts are often used to create an early successional habitat condition. Early successional habitat is when an area is in a young, shrubby, regenerating condition that covers an area large enough to be recognized and perhaps utilized by wildlife or plants associated with such an open or no-canopy condition.

This technique should be utilized when an early successional habitat condition is desired and found to be lacking or not available within the landscape. As mentioned previously in this description, clearcut size does have an impact on tree species composition, and therefore should also be utilized when current species composition is not desired or diverse enough to reach goals and objectives. This technique can be used in all habitat types, and although somewhat limiting in terms of emulating natural processes or conditions, can be used in a continual, progressive system that sustains multiple age classes through a coarse uneven-aged landscape perspective.